

to further enable those skilled in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

[0040] The embodiments herein achieve a method for predicting and reporting an expected remaining life of a reconfigurable battery pack to a user, a load, an apparatus which manages the load, or a system which manages the battery pack. The method includes receiving a usage parameter. Further, the method includes identifying a State of Health (SOH) of degraded cells and current capacity of the reconfigurable battery pack. Furthermore, the method includes determining a number of fresh cells for the usage parameter based on the SOH and the current capacity of the reconfigurable battery pack.

[0041] The embodiments herein achieve a method for predicting life of a reconfigurable battery pack. The method includes identifying a SOH of degraded cells, a capacity fade, and a number of battery modules or cells of the reconfigurable battery pack. Further, the method includes determining a load deviation based on the capacity fade; and determining whether the load deviation is exceeding a threshold. Further, the method includes detecting an end of life of the reconfigurable battery pack when the load deviation exceeds the threshold.

[0042] The embodiments herein provide a method for predicting life of a reconfigurable battery pack. The method includes identifying a SOH of degraded cells, a load deviation, and a number of battery modules of the reconfigurable battery pack. Further, the method includes determining a capacity fade based on the load deviation; and determining whether the capacity fade is exceeding a threshold. Further, the method includes detecting an end of life of the reconfigurable battery pack when the capacity fade exceeds the threshold.

[0043] Unlike the conventional systems and methods, the proposed method and system is robust, reliable, and departs from the approaches heretofore seen to predict the life of the reconfigurable battery pack based on the relation between the load deviation, the SOH, the capacity fade and the pack configuration. The proposed method avoids overly complex computation seen in conventional systems and methods for predicting the life of the reconfigurable battery pack, but nonetheless, counterintuitively, arrives at reliable results. The proposed method can be used to design the reconfigurable battery pack based on a desired pack life and the current deviation or load deviation.

[0044] Unlike the conventional systems and methods, a substantially optimal design criterion of the reconfigurable battery pack is provided for substantially optimal estimation of the capacity fade of the reconfigurable battery pack without extensive user intervention. Thus, amongst other results, a minimum number of fresh cells, modules (or any portion of the plurality of cells that are combined to form the battery pack) that need to be replaced so as to extend the life of the reconfigurable battery pack in a cost effective manner is provided.

[0045] A substantially optimal estimation of the capacity fade of the reconfigurable battery pack is assessed, as it depends on the interaction between the fresh and aged modules in the reconfigurable battery pack. Thus, the proposed battery management system is used to estimate the pack capacity fade of the reconfigurable battery pack based on the load deviation without any overly complex compu-

tation such as the type in the conventional art. In such manner, the logic components in the BMS may be substantially reduced. Similarly, embedded processing resources in the BMS may be significantly reduced along with clock rate, voltage, and current.

[0046] Further, a ratio of fresh cell and aged cell is determined to predict the performance of the reconfigurable battery pack based on a load gradient. The ratio is used as an input parameter to aid a reconfigurable battery pack engineer to develop the reconfigurable battery pack with an extended life.

[0047] Further, the proposed method, according to one or more embodiments is implemented in an onboard Battery Management System (BMS) to predict and report the probable life of the reconfigurable battery pack under a standard discharge condition. The proposed method is applicable for any lithium ion (Li-ion) energy battery cells pack under any cycling conditions. The probable or expected life of the battery pack is reported to a user, a load apparatus, or an external management system such as a vehicle management system, via communication circuit 108 by visual, audio, electronically, or by other suitable indicia such as a loud-speaker, LED array, output wire such as USB, on board diagnostic (OBDII), or serial RS-232 port, Bluetooth, NFC, RFID, ZigBee, 4G, LTE, wireless LAN or Wifi data connection. In an electric vehicle, for example, the expected life, and/or other metrics may be reported to the user on a video display on the dashboard, or via a data connection to a mobile terminal such as a cellphone, tablet, laptop, smart-watch, head mounted display, smart glasses, or other suitable user interface proximate to the vehicle or remotely, for example, at a service center or dealership.

[0048] The applications of such battery management system include a Battery Electric Vehicle (BEV), a Hybrid Electric Vehicle (HEV), an Electric Vehicle (EV), a Plug-In Hybrid Electric Vehicle (PHEV), or any suitable load benefiting from reconfigurable battery packs including a plurality of interconnected cells.

[0049] FIG.1 is schematic view of a battery management system 100 configured to predict and report the life of a reconfigurable battery pack 110, according to an embodiment. In an embodiment, the battery management system 100 includes a controller 102, a SOH determiner 104, a storage memory 106, and a communication circuit 108. The battery management system 100 communicates with the reconfigurable battery pack 110 through the communication circuit 108. In an embodiment, the reconfigurable battery pack 110 includes battery cells 112a, 112b, and 112c (Hereafter, label of the battery cells is 112 for convenience). For example, the reconfigurable battery pack 110 is placed at a bottom end of a vehicle or placed anywhere underneath of the vehicle. The reconfigurable battery pack 110 includes a plurality of battery modules each having the plurality of battery cells 112 located, for example, at a rear end of the vehicle. The reconfigurable battery pack 110 is used in the vehicle for supplying electric energy. The reconfigurable battery pack 110 is configured to be charged during a recuperative or regenerative braking phase, during infrastructure charging, or during solar trickle charging and to be discharged during phases of the vehicle propulsion or use of accessories. The reconfigurable battery pack 110 is formed by a pack of rechargeable battery cells 112 connected in series and/or parallel manner. In an example, the number of battery cells 112 in the reconfigurable battery pack 110 is